HANDBOOK FOR MATHEMATICS MAJORS

General Information for All Mathematics Options

and a Description of the Traditional Option

Department of Mathematics
Virginia Polytechnic Institute & State University

Revised June 2016
Introduction

The purpose of this handbook is to advise you, the mathematics student, about the Mathematics Department and the curriculum for the Bachelor of Science degree in Mathematics. There are four different paths or options that you may follow towards a BS degree in Mathematics: (1) The Traditional Option, (2) The Applied Computational Mathematics Option (ACM), (3) The Applied Discrete Mathematics Option (ADM), and (4) The Educational Option.

The Traditional Option, as its name implies, yields a broad and flexible background in mathematics. The other three options are more specialized. The ACM is designed for students who are confident that they want to have an applied mathematics career in an area closely associated with physics or some form of engineering. The ADM is designed for students who are confident that they want to have an applied mathematics career in an area closely associated with computer science, statistics, or actuarial science. The Education Option is designed for students who are confident that they want to teach high- or middle-school mathematics.

Often students will begin their studies in the Traditional Option, and later change to one of the other three options when they become surer of the path that they wish to pursue. One, however, can acquire many aspects of the three specialized options within the Traditional Option, because it also requires some degree of specialization in an applications area and provides career development features. The three specialized options are each less general, but bring particular career paths into sharper focus. Each of the four options provides an excellent foundation for graduate study, either in mathematics or in an applications area.

This handbook will give details about requirements that are common to all four options (such as the University Curriculum for Liberal Education), and it will also describe the graduation checksheet for the Traditional Option. Three other brochures are available from the Mathematics Department that describe the other three options more carefully and include their graduation checksheets.

Department Location

The Mathematics faculty offices are located on the 4th and 5th floors of McBryde. The departmental office is 460 McBryde. The receptionist on duty can answer many questions you may have and direct you to an appropriate person for answers to other questions. Course outlines, lists of reference texts for specific courses, and other general information brochures are also available.

The Scholarship Program

The department has several scholarship programs. The main ones are the Hatcher Scholarships, the John C. and Elsie M. Layman Scholarships, the Roselle Scholarship, the Caldwell Scholarships, the Rollins Scholarships, the Steeneck Scholarships, the Wells Scholarships, the Science Dean's Scholarship, the Richard L. and Georgia W. Kimball/Norfolk Southern Scholarship, Marion V.Eckert and Charlotte H.Eckert endowed Mathematics scholarship the Oehring Textbook Scholarships, and the Carl Persinger Endowed Scholarship.

The Hatcher Scholarship Fund was established in 1975 by the late T. W. Hatcher, head of the Mathematics Department from 1943 to 1963. Income from the endowment is placed in an operating account to be used for scholastic merit scholarships for undergraduates majoring in mathematics. As a general rule, 15-20 scholarships for up to $1,000 per year are awarded; distributed among incoming freshmen and continuing students.

The John C. and Elsie M. Layman Scholarships are principally merit scholarships for students from rural Virginia communities. The John C. and Elsie M. Layman funds are also used to reward undergraduate research. Professor Layman and his son, John W. Layman, were on the Mathematics faculty for a total of over forty years.

The Roselle Scholarship is awarded to a rising senior in mathematics and is chosen on a merit basis. Dr. Roselle came to Virginia Tech as a faculty member in 1974, became Dean of the Graduate School in 1979, and served as the University Provost from 1983-1987.
The Caldwell Scholarship is being endowed by Patricia Ann Caldwell, a prominent mathematics alum, and a member of the Board of Directors of the Virginia Tech Foundation. The scholarship is intended for out-of-state women and is based on achievement, character, and appreciation of mathematics.

The Rollins Scholarship is given in honor of Prof. Forrest Rollins, who was a long-standing Mathematics Faculty member and also a dean of Arts & Sciences.

The Steeneck Scholarships are given in honor of Lee and Regina Steeneck who were both 1970 graduates of Virginia Tech. The scholarships are awarded to Mathematics majors with strong concentrations in Computer Science, with preference to students from Connecticut, New York, or Virginia.

The Wilbur Francis Wells Scholarships are based on merit and need, and are principally for students from either Brentsville High School or Osbourn High School.

The Dean's Scholarship of $1,000 is given to an entering freshman and is funded by the Dean of the College of Science.

The Richard L. and Georgia W. Kimball/Norfolk Southern Scholarship is given in honor of Norfolk Southern Corporation and is based on merit.

The Marion V. Eckert and Charlotte H. Eckert endowed Mathematics scholarship is awarded to Virginia residents with preference given to freshmen and is based on merit and need.

The Charles Oehring Textbook Scholarships were established to honor long time Mathematics faculty member, Charles Oehring, and are based on merit and need.

The Carl Persinger Endowed Scholarship is based on merit and need. Carl Persinger was one of the three students who received the first PhD’s from the Department of Mathematics in 1965.

For further scholarship information, contact Dr. Robert Rogers or the chairman of the Mathematics Scholarship Committee.

Governance of the Undergraduate Curriculum

The Undergraduate Mathematics Curriculum is ultimately governed by the Mathematics Faculty and the Department Head. However, the faculty and head are advised by the Undergraduate Program Advisory Committee (UPC) and advisory committees for each of the three specialized options. These committees are concerned with all matters pertaining to the curriculum of the undergraduate mathematics majors. The committees discuss all suggested changes in requirements, all suggested changes in 3000- and 4000-level mathematics courses in the curriculum, and all suggested new texts. Finally, the committees rule on requests of individual majors to depart from the standard programs.

Student Advisors

You are assigned a faculty advisor to help you in planning your undergraduate program and to help you in registering for classes. An attempt is made to keep you with the same advisor for your entire undergraduate career. Your advisor and Lori Berry will keep records of your progress toward a degree and keep you posted on these matters. You will also be aided by your advisor in settling difficulties that may arise with the Registrar's Office at the time of your graduation.

In addition to your specific advisor, the Mathematics Department has a designated Career Advisor, Dr. Stanca Ciupe. Her task is to work with your academic advisor in providing you with information which will aid you in planning a career-oriented program. Materials concerning careers and campus interviews are regularly posted on the bulletin board on the northwest wall of fourth floor, McBryde Hall. In connection with this endeavor, you can look online at “Career Preparation” (http://www.math.vt.edu/ugCareerPreparation.php).
The Undergraduate Mathematics Curriculum

The curriculum of each of the four options is designed to give you a solid foundation in the basic areas of mathematics with supporting background in allied areas. The specific requirements are:

University:

(1) All students are required to have a 2.000 QCA for all courses attempted, and for all courses in the student’s major. The in-major QCA is not printed on the grade report, but is available on request in McBryde 460 and on your DARS report.

(2) No course used to fulfill major, minor, or University/College Curriculum for Liberal Education requirements may be taken pass/fail.

(3) Only students with QCA’s of 2.5 or above and who have completed at least 30 credit hours at Virginia Tech may take elective courses pass/fail (unless the course is offered only P/F). Students may take no more than 10% of the hours taken at Virginia Tech on a P/F basis. The 10% limit includes courses offered P/F only.

(4) Of the 120 hours required for graduation, a student may count no more than 2 hours of Physical Education activity credit, 8 hours of Music Ensemble (MUS 3314 and 3414), and 8 hours of Independent Study and/or Undergraduate Research (2974, 2994, 4974, 4994). There is a University foreign language requirement, but it is covered by the more stringent Science requirement (see below).

College: The College of Science requires a total of 120 hours. All courses used for Curriculum for Liberal Education must be on the approved Curriculum for Liberal Education list, but there is no longer a laboratory requirement in Area 4. (Licensure for secondary teaching, however, does require the labs from the sequence in Area 4; Biology, Chemistry, Geosciences, Environmental Science, or Physics. Mathematics majors must take Math 1225-1226 or its equivalent to satisfy the Area 5 Curriculum for Liberal Education requirement.

(1) A maximum of 60 hours in mathematics courses.

(2) FOREIGN LANGUAGES: Successful completion of one of the following:
   a) The third year (level III) of one foreign language in secondary school.
   b) The 1106 course in Chinese, French, German, Greek, Italian, Japanese, Latin, Portuguese, Russian, or Spanish, including any prerequisites.
      
      (i) With two years of high school credit, 1105 can be taken P/F, but 1106 must be A/F. Both 1105 and 1106 may be used as hours of credit towards graduation.

      (ii) With less than two years of high school credit, both 1105 and 1106 must be taken A/F, but neither can be used as hours of credit towards graduation.

   c) A score of 500 or more on the CEEB Achievement Test.
   d) An examination in a language not taught at Virginia Tech with consent of the Department of Foreign Languages; arrangements made through the department (does not carry credit towards graduation).

(3) WRITING AND DISCOURSE (Area 1 - Freshman English): Successful completion of one of the following:

   a) ENGL 1105, 1106; or ENGL 1204H.
   b) ENGL 1106, if student received Advanced Standing (with credit) for ENGL 1105.
   c) Advanced-Placement Score of 4 or 5.
(4) **HUMAN IDEAS, CULTURAL TRADITION, AND VALUES** (Area 2 - Mostly Humanities) (6 hours)

(5) **SOCIETY AND HUMAN BEHAVIOR** (Area 3 - Mostly Social Sciences) (6 hours)

(6) **SCIENTIFIC REASONING AND DISCOVERY** (Area 4 - Natural Sciences):

Any of the six-hour sets listed below. (Math Ed requires the lab and will need an eight-hour set.)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1005, 1006</td>
<td>General Biology</td>
</tr>
<tr>
<td>BIOL 1015, 1016</td>
<td>General Biology Laboratory</td>
</tr>
<tr>
<td>BIOL 1105, 1106</td>
<td>Principles of Biology</td>
</tr>
<tr>
<td>BIOL 1115, 1116</td>
<td>Principles of Biology Laboratory</td>
</tr>
<tr>
<td>BIOL 1205, 1206</td>
<td>Honors Biology (Includes Lab)</td>
</tr>
<tr>
<td>CHEM 1015, 1016</td>
<td>Introduction to Chemistry</td>
</tr>
<tr>
<td>CHEM 1025, 1026</td>
<td>Introduction to Chemistry Laboratory</td>
</tr>
<tr>
<td>CHEM 1035, 1036</td>
<td>General Chemistry</td>
</tr>
<tr>
<td>CHEM 1045, 1046</td>
<td>General Chemistry Laboratory</td>
</tr>
<tr>
<td>ENSC 1015, 1016</td>
<td>Foundations of Environmental Science</td>
</tr>
<tr>
<td>ENSC 1115, 1116</td>
<td>Foundations of Environmental Science Laboratory</td>
</tr>
<tr>
<td>GEOS 1004, 1024</td>
<td>Physical Geology and Resources Geology</td>
</tr>
<tr>
<td>GEOS 1104, 1124</td>
<td>Physical Geology Lab and Resources Geology Lab</td>
</tr>
<tr>
<td>GEOS 1004, 1014</td>
<td>Physical Geology and The Earth &amp; Life Through Time</td>
</tr>
<tr>
<td>GEOS 1104</td>
<td>Physical Geology Lab (Lab included in GEOS 1014)</td>
</tr>
<tr>
<td>PHYS 1055, 1056</td>
<td>Introduction to Astronomy</td>
</tr>
<tr>
<td>PHYS 1155, 1156</td>
<td>Astronomy Laboratory</td>
</tr>
<tr>
<td>PHYS 2205, 2206</td>
<td>General Physics (Not recommended for Mathematics students)</td>
</tr>
<tr>
<td>PHYS 2215, 2216</td>
<td>General Physics Laboratory</td>
</tr>
<tr>
<td>PHYS 2305, 2306</td>
<td>Foundations of Physics I (Includes Lab)</td>
</tr>
</tbody>
</table>

(7) **QUANTITATIVE AND SYMBOLIC REASONING** (Area 5):

Mathematics majors satisfy this requirement by taking Math 1225-1226.

(8) **CREATIVITY AND AESTHETIC EXPERIENCE** (Area 6 - Visual and Performing Arts) (3 hours).

(9) **CRITICAL ISSUES IN A GLOBAL CONTEXT** (Area 7) (3 hours)
Department (Satisfactory progress toward the BS in Mathematics): Satisfactory progress toward the Bachelor of Science degree in Mathematics involves required 1000-level and 2000-level math classes and Math 3034. Refer to the Mathematics Traditional Option checksheet for details on specific progress to degree requirements.

Department (Traditional Option¹): The university and college requirements are supplemented by the following departmental requirements:

(1) A minimum of 44 hours of mathematics, including 1225-1226, 2204, 2114, 2214, 3034, 3124, 3214, 3224, 3144, and 12 hours of 4000-level mathematics subject to the restrictions on the Guide Sheet at the end of this booklet.

(2) A minimum of 15 hours of math-related coursework. See “Math-Related Courses” on the next page of this handbook.

Comments on the Traditional Curriculum

A. Math Requirements:

Math 1225 and 1226 are the standard mathematics courses for your freshman year. These courses introduce you to the language, techniques and applications of elementary calculus. Credit is available for Math 1225 and 1226 through the C.E.E.B. calculus advanced-placement test. Incoming freshmen should check with the summer orientation advisor about AP credit and about credit-by-examination.

Paralleling the standard versions of Math 2214 and 2204 are "honors" sections of the same material. Honors sections cover the material in more depth than standard courses and include a few extra topics. However, there is no material presented in regular sections that is not also covered in honors sections. Admission to honors sections is by invitation only. If you are interested in honors classes and you did not receive an invitation based upon your high school record, you should consult with the chairman of the honors program, the assistant chair in mathematics, or your advisor.

In addition to Math 2214 and 2204, Math 3034 should be taken during the sophomore year. (Note the "C or better" prerequisite for 3034 given in the advice on the last page of this document.) Much of Math 3034 is an introduction to creating logical proofs. This course bridges a gap between the largely manipulative nature of the calculus sequence and the fundamental-reasoning nature of the junior-level courses. The difference between calculus and higher-level mathematics courses is analogous to the difference between high school algebra and high school geometry.

The junior-level courses are Math 3124 (modern algebra), Math 3214 (a course in the calculus of several variables), Math 3224 (an advanced treatment of the calculus of the freshman year), and Math 3144 (an advanced treatment of the linear algebra begun in 2114). These courses should not be viewed as applied courses, but rather as courses that build mathematical foundations necessary for most senior-level courses. Exceptional students may substitute Math 4124 for 3124, Math 4225 for Math 3214, and/or Math 4226 for Math 3224.

There are a wide variety of 4000-level courses. The student should select these courses to augment his or her chosen applications area. One may also choose fundamental extensions of junior-level courses in preparation for graduate school. Twelve hours are required. Six of these hours must come from a sequence or cluster listed on the Guide Sheet at the end of this handbook. Not more than one course is allowed from 4044, 4334, and 4344. Not more than one course is allowed from 4564 and 4425. With departmental permission, advanced students are also allowed to take graduate courses.

¹See the mathematics course requirements for the other three options in their respective brochures.
B. Math-Related Courses:

A coherent program of courses in fields other than mathematics, but in which mathematics is used significantly, is valuable as part of a general education in mathematics and is extremely valuable for employment opportunities. In light of this, you are required to work with your advisor to complete a plan of “math-related courses.” The plan should be submitted for approval of the Undergraduate Program Committee by the end of your second year at Virginia Tech. The plan must meet the following requirements:

1. It must contain at least 15 credits of course work.
2. At least three credits must be in a computer programming course. (Math 3054, Programming for Mathematical Problem Solving, is a very good option for this.)
3. These courses should be from departments other than Mathematics. (Math 3054 is an exception. Independent Study or Field Study course is sometimes allowed as a math-related course.)
4. The plan must exhibit depth in at least one application area.
5. The plan must contain courses with advanced mathematical content.

Popular concentrations recently have been in computer science, actuarial science, operations research, statistics, and physics.

A form to be filled out with the help of your advisor is included on the next page.

C. Electives:

There are at least 25 hours of free electives in this curriculum. (You may obtain more electives by selecting math-related courses which also satisfy other requirements.) Exercise care in choosing your electives. You have opportunities at a university which exist nowhere else. Choosing electives is one way for you to tailor your formal education individually. The ability to choose your own applications area and free electives makes this degree both strong and flexible.

(Usually if you do not have a prerequisite for a course, you should not take the course. Sometimes, however, the listed prerequisites are not absolutely necessary or are made unnecessary by other work you have done. To corroborate the necessity of the prerequisite, you can contact a faculty member from the department of the course.)
Virginia Tech Department of Mathematics

Traditional Option Math Related Course Plan

As part of its Traditional Option, the Department of Mathematics requires a 15 credit plan of “Math-Related Courses.” The requirements for the plan are found in the *Handbook for Mathematics Majors*. The plan should be submitted by the end of your second year at Virginia Tech.

**Instructions for submitting the plan:** (1) List a coherent program of courses at least 15 credits meeting the requirements listed in the Handbook. (2) Attach a short explanation and justification for your plan. Address the intellectual rigor of the courses and the overall program, the degree to which mathematics is used, and the relevance to your career and/or future studies. (3) Sign the petition and obtain the signature of your academic advisor. (4) Submit two copies of the petition to the Undergraduate Secretary, Lori Berry, 460 McBryde Hall.

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Student Name & ID: __________________________________________

Student Signature: __________________________________________ Date: ______

Advisor Signature: _________________________________________ Date: ______
SPECIAL OPPORTUNITIES FOR ALL MATHEMATICS MAJORS

The Mathematics Honors Program

The honors program in mathematics, an extension of the honors calculus sequences, leads to the degree of Bachelor of Science in Mathematics in Honors. The requirements for participation in the Honors Program are: for freshmen, a cumulative GPA of 3.70 (as reported on their high school transcript) and a minimum SAT score of 1350 (critical reading and mathematics) or a minimum ACT composite score of 30; for upperclassmen, provided they have at least four (4) semesters remaining before they graduate, the minimum requirement is a 3.6 QCA for studies completed at Virginia Tech. Several academic departments in the College of Sciences offer special Honors sections of their courses. In addition to special sections of some courses, the Honors Office sponsors a colloquia series each semester. The colloquia explore special topics not in the University Curriculum.

There are three major ways in which students can participate in Honors. The first is as a Virginia Tech Commonwealth Scholar. Scholars enjoy such privileges as priority registration and the right to take Honors courses. Commonwealth Scholars must take 12 hours of Honors credits. Second is as an Honors Scholar. Honors Scholars must take 18 hours of Honors credits. Thirdly, it is also possible to graduate with a degree "in Honors." Students seeking the "in Honors" degree must complete 21 hours of Honors credits including 6 credits of Honors Undergraduate Research, and an Honors thesis.

For more details, contact the Honors Advisor.

Undergraduate Research

Mathematics majors are encouraged to sign up for Math 4994 - Undergraduate Research to obtain an experience in mathematical research. A brochure on Undergraduate Research is available from the math office or from the Chairman of the Undergraduate Research Committee. The department currently sponsors the John C. and Elsie M. Layman Prize competition for the best project and paper in Undergraduate Research. For further details, go to http://www.math.vt.edu/ugResearch.php.

Five Year Combined Bachelor/Master's Program in Mathematics

The five-year B.S./M.S. program is intended to allow especially talented undergraduate students to progress quickly into graduate-level study. The principal feature of the program is that it allows the students to use 12 hours of graduate work simultaneously toward the completion of their bachelor's degree and a program of study leading to a master's degree. It is this ability to complete the final year of undergraduate work with the same courses that comprise the first year of graduate work that makes it possible to finish both degrees in 5 years. Undergraduates are eligible to apply for the program after they have completed 75 hours and have a QCA of at least 3.5. For more information, students should contact the Math Department Graduate Program Director, Shu-Ming Sun, or Chair, Peter Haskell.

Dual Majors

The Registrar has permission to list two majors on your undergraduate transcript if you satisfy graduation requirements for two curricula and request the Registrar to list both. Dual majors with computer science, engineering, statistics, or physics are popular choices that yield excellent degrees. You may obtain two diplomas by taking an additional 30 hours of coursework beyond the requirements of the primary major.

Minors

Any department which offers a major may offer a minor. If you desire a minor in a particular discipline, contact the appropriate department for their requirements. Minors will be listed on your undergraduate transcript.
The Cooperative Education Program

As a math major, you are encouraged to participate in the Co-op Program. This program allows you to integrate some work experiences with your academic studies. In the program you spend your first year on campus, then alternate terms between industry and college for three years, and finally spend all of your senior year on campus. You can gain experience as well as help finance your education under the Co-op plan. For more details you are invited to visit the Co-op office in the Career Services Building or see the Mathematics Career Advisor.

Activities

Undergraduate and graduate students in mathematics are invited to join the Virginia Tech university chapters of MAA (The Mathematical Association of America) and SIAM (Society of Industrial and Applied Mathematics). The activities of these chapters include talks on mathematics used in government and industry, as well as social, recreational, and charitable activities.

Tech has a chapter of Pi Mu Epsilon, a national organization whose purpose is the promotion of scholarly activity in mathematics. Outstanding math majors may be nominated for membership in this organization in their junior or senior years.

The Putnam Mathematics Examination

Each December a nationwide mathematics examination, the William Lowell Putnam Competition, is given. The examination is graded for individual performances and carries a considerable amount of prestige. In addition, each participating school selects three students whose composite score represents the school. Cash prizes are awarded to the schools whose teams rank in the top five and to the members of those teams. The individuals with the top ten scores are also awarded prizes. Finally, small cash prizes are given by the Math Department to the students who rank one, two and three among the students taking the test at Tech.

The most essential feature of the examination is that it does not test for knowledge acquired in courses. Anyone who has had calculus and ordinary differential equations is prepared to work the problems. This means that all the problems are elementary, but often quite tricky. The only way for you to prepare for the examination is to practice on previous examinations or similar problems. To this end, problem seminars are organized in the fall to work through previous examinations and to select a team for the upcoming examination. These seminars and the experience of the examination can be a rewarding mathematical experience for you. You will learn techniques which are applicable to concrete problems and will develop self-reliance in mathematics. Anyone who has a "feel" for mathematics should attend the seminars, not just math majors in the upper classes. For further information, contact Dr. Martin Klaus, 472 McBryde, klaus@math.vt.edu.

Locally Sponsored Mathematics Competitions

The faculty, alumni and friends of the Mathematics Department sponsor two contests each year, one in the fall and the other in the spring. The fall competition is open to all undergraduates at Tech and at other regional colleges and universities. It is similar in nature to the Putnam examination, although it is intended to be easier. The spring competition is open to all freshmen and sophomores at Tech. This test is based upon the material covered in the freshman/sophomore courses; Math 1225-1226, 2114, and 2214. Cash prizes are awarded to the winners of each of these contests. For further information, contact Dr. Peter Linnell, 516 McBryde, linnell@math.vt.edu.

Senior Award

In each of the four degree options, one student is selected each year as the outstanding senior. These students are given special recognition and an appropriate plaque at the commencement exercises for that class.
Preparation for Post-Graduate Endeavors

Whether you plan to seek employment immediately upon graduation or attend graduate school, you need to start investigating and planning during the latter part of your junior year. You should make use of the Career Services office, the Math Department web pages, the Internet, and Dr. Stanca Ciupe, the Mathematics Career Advisor. (See the Career Services Web site: http://www.career.vt.edu/)

If you are seeking employment, you should complete a résumé during the summer between your junior and senior years. (This document should also be placed in an electronic file which can be included as part of your own internet homepage, and can be used later if you use the University’s Candidate Referral Service. Contact us for homepage instructions. You will submit a résumé for every on-campus interview for which you apply, and you will include it in your letters of inquiry. (Remember the old cliché, “You never get a second chance to make a good first impression.”)

You can pick up a free Placement Manual at the Career Services office in the Career Services Building. You definitely want to see who is interviewing on campus, and also to see lists of companies that are hiring, but not interviewing. These two lists include dates for interviews, résumé drops, priority sign-ups, and open sign-ups.

In the present economic climate, most jobs are found by directly contacting companies; even ones who are not interviewing on campus or ones who do not say they will interview mathematics majors. Talk to a career advisor or the Career Services office about the best ways to make these contacts. IMPORTANT: Be sure that you never attend an interview without being fully informed about the company/agency and its work.

If you plan to go to graduate school, you should make preliminary inquiries about graduate schools before the end of your junior year. (Again see our departmental career Web site.) Also talk to professors that may have attended the graduate school in which you are interested, and consult the graduate catalogs on the third floor of the library.) At the beginning of your senior year, you should start writing for application forms, both for admission and for financial aid. Many graduate schools require the Graduate Record Examination. Plan to take it in October of your senior year. Finally, allow enough time for professors to write your letters of reference.

You may wish to consider graduate work in a field other than mathematics; probably in the area of your applied concentration. One need not have a B.S. in a discipline in order to do graduate work in that area. There will, of course, be certain basic courses that you will be expected to have had. You or your advisor can easily check with the other discipline about these courses.

Some of the general areas where majors in mathematics find employment are listed below. After each title, some courses which should help you in the area are listed. Additional information about employment can be found in the handbook on Mathematical Careers or from a career advisor.

**Actuarial Science**

The Statistics Department offers a minor in actuarial science that includes courses in probability and statistics (STAT 3005-3006, STAT 4105, STAT 4214, STAT 4534, and STAT 4706), economics (ECON 2005-6), and finance (FIN 3104, FIN 3134). Go to http://www.stat.vt.edu/undergraduate/actuarial-science.html for more information.

**Business**

Include the same courses as for actuarial science, with perhaps less emphasis on statistics and more on economics. Business Law (FIN 3055-6) is a nice elective for a career in business.

**Operations Research**

Include courses in probability and statistics (Stat 4105-6 or 4705-6), computer science (at least CS 1044, 1054, and 1114), operations research (ISE 2404, 3414, 3424, 3614, 4404), and numerical analysis (Math 4445-6).
Statistics
Take theoretical statistics (Stat 4105-6) and choose from specific areas. A statistics minor would be valuable.

Computer Science
Take CS 1044, 1054, 1114 and choose from specific computer science areas. A computer science minor would be valuable.

Finance
Take ACIS 2004, FIN 3104, and FIN 4174. Other recommended courses are ECON 2005-2006, FIN 4114, FIN 4124, and FIN 4144. The Finance courses rely on a statistical foundation such as is found in STAT 2004 or 3104.
MATHEMATICS GUIDE SHEET

FOR THE

TRADITIONAL OPTION

Mathematics Courses

1. Twelve semester hours must be 4000-level. (Any 5000-level Mathematics course may be substituted for a 4000-level course.) No 46xx course may be used for these required 12 hours.

2. Not more than one course is allowed from 4044, 4334, and 4344. A student may not use both 4425 and 4564.

3. Math 4574 may not be taken for credit by Mathematics majors.

4. A sequence or cluster must be completed from one of the following two-course sets:

   [4225-6]; [4245-6]; [4425-6]; [4445-6]; [4225, 4234]; [4245, 4254]; [4245, 4454]; [4245, 4425]; [4414, 4445]; [4414, 4446]; [4445, 4446]; [5454, 5464]; [any two of 4124, 4134, 4144, 4175, 4176, 5114].

5. 4974, 4984, and 4994 can be used only with the express approval of the Undergraduate Program Committee.

ADVICE

Pass-Fail: All courses taken under the headings 1, 2, and 3 must be taken for grade.

1: Refer to the Mathematics Traditional Option checksheet for requirements of enrollment in Math 3034.

2: Math-related courses are (a) fundamental to a discipline that uses a significant amount of advanced mathematics and (b) courses that use mathematical constructions or concepts that are at least as sophisticated as freshman calculus.

One of CS 1044, 1054, 1114 or Math 3054 is required.

3: Area 1. The appropriate freshman English placement is done automatically by the Director of Freshman English.

Foreign Language. Proficiency equivalent to one year of university instruction must be demonstrated in one foreign language. High school language III (e.g. German III) or a sufficient score on a placement test or achievement test will satisfy this requirement.

Courses in Curriculum for Liberal Education categories must come from the approved lists found in the on-line table of classes.

4: There are at least 25 hours of electives; usually more if departmental and college requirements are combined. The Mathematics Department recommends more mathematics courses than the minimum number (but more than 60 hours is not permitted) or, more math-related courses.
SAMPLE PROGRAM OF STUDY
There is considerable flexibility in designing a program of study. The example given below is not likely to fit every situation and is provided for information as you develop your own plan with your advisor.

Bachelor of Science (B.S.) in MATH (BS MATH) - Traditional Option, Path 2 (new calculus sequence)

<table>
<thead>
<tr>
<th>Freshman</th>
<th>1st Semester</th>
<th>2nd Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 1105</td>
<td>Freshman English (Area 1)</td>
<td>3</td>
</tr>
<tr>
<td>MATH 1225</td>
<td>Calculus of a Single Variable</td>
<td>4</td>
</tr>
<tr>
<td>MATH 2984</td>
<td>SS: Discovering Mathematics I</td>
<td>1</td>
</tr>
<tr>
<td>Area 2 - Ideas, Cultural Traditions and Values</td>
<td>3</td>
<td>Area 2 - Ideas, Cultural Traditions and Values</td>
</tr>
<tr>
<td>Area 3 - Society and Human Behavior</td>
<td>3</td>
<td>Area 6 - Creative and Aesthetic</td>
</tr>
<tr>
<td>Free Elective</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sophomore</th>
<th>1st Semester</th>
<th>2nd Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 2114</td>
<td>Introduction to Linear Algebra 1</td>
<td>3</td>
</tr>
<tr>
<td>MATH 2204</td>
<td>Intro Multivariable Calculus</td>
<td>3</td>
</tr>
<tr>
<td>Area 3 - Society and Human Behavior</td>
<td>3</td>
<td>Area 4 – Scientific Reasoning and Discovery</td>
</tr>
<tr>
<td>Area 4 – Scientific Reasoning and Discovery</td>
<td>3</td>
<td>Free Elective</td>
</tr>
<tr>
<td>Area 7 - Critical Issues</td>
<td>3</td>
<td>Free Elective</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Junior</th>
<th>1st Semester</th>
<th>2nd Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 3124</td>
<td>Modern Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 3214</td>
<td>Calculus of Several Variables</td>
<td>3</td>
</tr>
<tr>
<td>MATH 3054</td>
<td>Programming for Math (or CS 1044, 1054, 1114)</td>
<td>3</td>
</tr>
<tr>
<td>Free Elective</td>
<td>3</td>
<td>Free Elective</td>
</tr>
<tr>
<td>Free Elective</td>
<td>3</td>
<td>Free Elective</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Senior</th>
<th>1st Semester</th>
<th>2nd Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 4xxx</td>
<td>4000-level sequence</td>
<td>3</td>
</tr>
<tr>
<td>MATH 4xxx</td>
<td>4000-level math course</td>
<td>3</td>
</tr>
<tr>
<td>Math-Related Course</td>
<td>3</td>
<td>Math-Related Course</td>
</tr>
<tr>
<td>Math-Related Course</td>
<td>3</td>
<td>Free Elective</td>
</tr>
<tr>
<td>Free Elective</td>
<td>3</td>
<td>Free Elective</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

1 If you do not have Math 1114 credit prior to fall 2014, take Math 2114 instead. Check prerequisites to determine the appropriate semester to take Math 2114.